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Section 7.1 Describing Reactions

(pages 192–198)

This section discusses the use of chemical equations and how to balance them. It also demonstrates the use of calculations in chemistry.

Reading Strategy (page 192)

Monitoring Your Understanding Preview the Key Concepts, topic headings, vocabulary, and figures in this section. List two things you expect to learn. After reading, state what you learned about each item you listed. For more information on this Reading Strategy, see the **Reading and Study Skills** in the **Skills and Reference Handbook** at the end of your textbook.

What I Expect to Learn	What I Learned
Answers may vary. Possible answers: How to balance chemical equations	Answers may vary. Possible answers: An unbalanced equation can be balanced by changing the coefficients.
How to convert from mass to moles	The mass of a substance can be converted to moles by using the molar mass as a conversion factor.

Chemical Equations (pages 192–193)

1. Is the following sentence true or false? The new substances formed as a result of a chemical reaction are called products. true

2. Circle the letter of each sentence that is a correct interpretation of the chemical equation $C + O_2 \longrightarrow CO_2$.

a. Carbon and oxygen react and form carbon monoxide.

(b.) Carbon and oxygen react and form carbon dioxide.

c. Carbon dioxide yields carbon and oxygen.

(d.) The reaction of carbon and oxygen yields carbon dioxide.

3. Is the following sentence true or false? The law of conservation of mass states that mass is neither created nor destroyed in a chemical reaction. true

4. Circle the letter of the correct answer. According to the equation $C + O_2 \longrightarrow CO_2$, how many carbon atoms react with 14 molecules of oxygen to form 14 molecules of carbon dioxide?

a. 1 b. 7

(c.) 14 d. 28

5. In the reaction represented by the equation $C + O_2 \longrightarrow CO_2$, the mass of carbon dioxide produced equals the total mass of carbon and oxygen that reacted _____.

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Balancing Equations (pages 194–195)

6. Is the following sentence true or false? A chemical equation must be balanced in order to show that mass is conserved during a reaction. true

7. Circle the letter of the name given to the numbers that appear before the formulas in a chemical equation.

   a. subscripts b. mass numbers

   c. atomic numbers (d.) coefficients

8. Is the following sentence true or false? Because the equation $N_2H_4 + O_2 \longrightarrow N_2 + H_2O$ has two nitrogen atoms on each side, the equation is balanced. false

Counting With Moles (pages 195–196)

9. Chemists use a counting unit called a(n) mole to measure amounts of a substance because chemical reactions often involve large numbers of small particles.

10. Circle the letter of the correct answer. If one carbon atom has an atomic mass of 12.0 amu and one oxygen atom has an atomic mass of 16.0 amu, what is the molar mass of carbon dioxide?

    a. 28.0 amu b. 44.0 amu

    c. 28.0 g (d.) 44.0 g

11. Circle the letter of the correct answer. To convert grams of carbon dioxide to moles of carbon dioxide, you must multiply by which conversion factor?

    a. $\frac{44.0\text{ g } CO_2}{1\text{ mol } CO_2}$ (b.) $\frac{1\text{ mol } CO_2}{44.0\text{ g } CO_2}$

    c. $\frac{28.0\text{ g } CO_2}{1\text{ mol } CO_2}$ d. $\frac{1\text{ mol } CO_2}{28.0\text{ g } CO_2}$

Chemical Calculations (pages 197–198)

12. Complete the table.

Formation of Water			
Equation	$2H_2$ + O_2	$\longrightarrow$	$2H_2O$
Amount	2 mol	1 mol	2 mol
Molar Mass	2.0 g/mol	32.0 g/mol	18.0 g/mol
Mass (Moles × Molar Mass)	4.0 g	32.0 g	36.0 g

13. Circle the letter of the correct answer. One mole of oxygen has a mass of 32 grams. What is the mass of four moles of oxygen?

    (a.) 128 g b. 144 g

    c. 128 amu d. 144 amu

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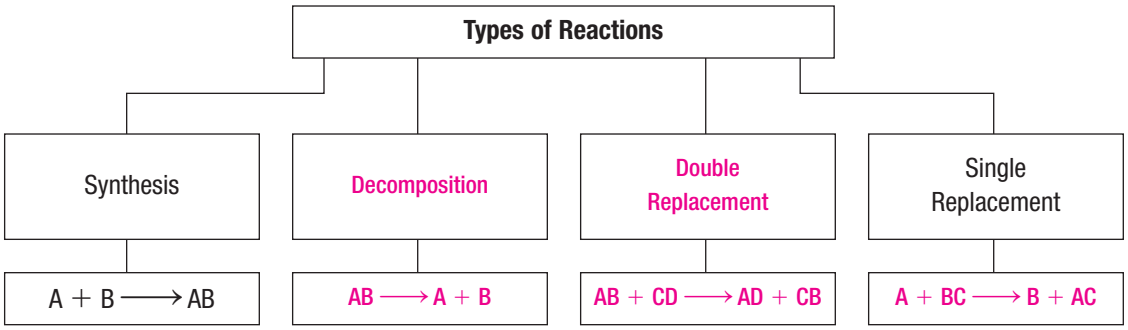
Section 7.2 Types of Reactions

(pages 199–205)

This section discusses how chemical reactions are classified into different types.

Reading Strategy (page 199)

Previewing Skim the section and begin a concept map like the one below that identifies types of reactions with a general form. As you read, add the general form of each type of reaction. For more information on this Reading Strategy, see the **Reading and Study Skills** in the **Skills and Reference Handbook** at the end of your textbook.



Classifying Reactions (pages 199–204)

1. Name five general types of chemical reactions. Synthesis, decomposition, single replacement, double replacement, and combustion

2. Circle the letter of each equation that represents a synthesis reaction.
   (a.) $2Na + Cl_2 \longrightarrow 2NaCl$
   b. $2NaCl \longrightarrow 2Na + Cl_2$
   c. $2H_2O \longrightarrow 2H_2 + O_2$
   (d.) $2H_2 + O_2 \longrightarrow 2H_2O$

3. Is the following sentence true or false? A decomposition reaction is the opposite of a synthesis reaction. true

4. Write the equation for the decomposition of calcium carbonate into calcium oxide and carbon dioxide. $CaCO_3 \longrightarrow CaO + CO_2$

5. Circle the letter of the correct answer. Copper reacts with silver nitrate in a single-replacement reaction. What are the products of this reaction?
   a. copper(II) nitride and silver oxide
   (b.) copper(II) nitrate and silver
   c. copper(II) oxide and silver nitrate
   d. copper, nitrogen, and silver oxide

6. What is a double-replacement reaction? A double-replacement reaction is a reaction in which two different compounds exchange positive ions and form two new compounds.

7. Complete the chart by filling in the general forms of the reactions shown.

General Forms	
Single-Replacement Reaction	**Double-Replacement Reaction**
$A + BC \longrightarrow B + AC$	$AB + CD \longrightarrow AD + CB$

8. Lead(II) nitrate reacts with potassium iodide to form lead(II) iodide and potassium nitrate. Write the balanced equation for this double-replacement reaction. $Pb(NO_3)_2 + 2KI \longrightarrow PbI_2 + 2KNO_3$

9. Circle the letter of the correct answer. Calcium carbonate, $CaCO_3$, reacts with hydrochloric acid, HCl, in a double-replacement reaction. What are the products of this reaction?
   a. calcium chloride, $CaCl_2$, and carbonic acid, H_2CO_3
   b. calcium hydride, CaH_2, chlorine, Cl_2, and carbon dioxide, CO_2
   c. calcium hydrogen carbonate, $Ca(HCO_3)_2$, and chlorine, Cl_2
   d. calcium perchlorate, $Ca(ClO_4)_2$, and methane, CH_4

10. Is the following sentence true or false? A combustion reaction is a reaction in which a substance reacts with carbon dioxide, often producing heat and light. false

11. Methane, CH_4, burns in oxygen to form carbon dioxide and water. Write the balanced equation for this reaction. $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

12. Is the following sentence true or false? The reaction that forms water can be classified as either a synthesis reaction or a combustion reaction. true

Reactions as Electron Transfers (pages 204–205)

13. What is an oxidation-reduction reaction? An oxidation-reduction reaction is a reaction in which electrons are transferred from one reactant to another.

14. Calcium reacts with oxygen to form calcium oxide. Which reactant is oxidized in this reaction? calcium

15. Is the following sentence true or false? When calcium reacts with oxygen, each calcium atom gains two electrons and becomes a calcium ion with a charge of 2–. false

16. Is the following sentence true or false? Oxygen must be present in order for an oxidation-reduction reaction to take place. false

17. The process in which an element gains electrons during a chemical reaction is called reduction.

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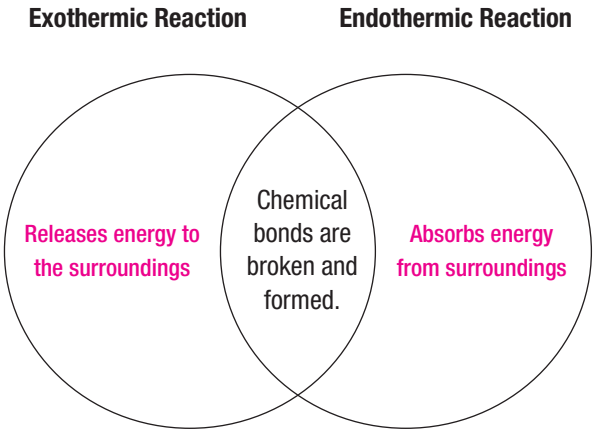
Section 7.3 Energy Changes in Reactions
(pages 206–209)

This section discusses how chemical bonds and energy relate to chemical reactions.

Reading Strategy (page 206)

Comparing and Contrasting As you read, complete the Venn diagram below to show the differences between exothermic and endothermic reactions. For more information on this Reading Strategy, see the **Reading and Study Skills** in the **Skills and Reference Handbook** at the end of your textbook.



Chemical Bonds and Energy (pages 206–207)

1. What is chemical energy? Chemical energy is the energy stored in the chemical bonds of a substance.

2. Chemical reactions involve the breaking of chemical bonds in the reactants and the formation of chemical bonds in the products.

3. Is the following sentence true or false? The formation of chemical bonds absorbs energy. false

4. What role does the spark from the igniter play in the reaction that takes place when propane is burned in a gas grill? The spark provides enough energy to break the bonds of reacting molecules and get the reaction started.

5. Is the following sentence true or false? The heat and light given off by a propane stove result from the formation of new chemical bonds. true

6. The combustion of one molecule of propane (C_3H_8) results in the formation of 6 C=O double bonds and 8 O−H single bonds.

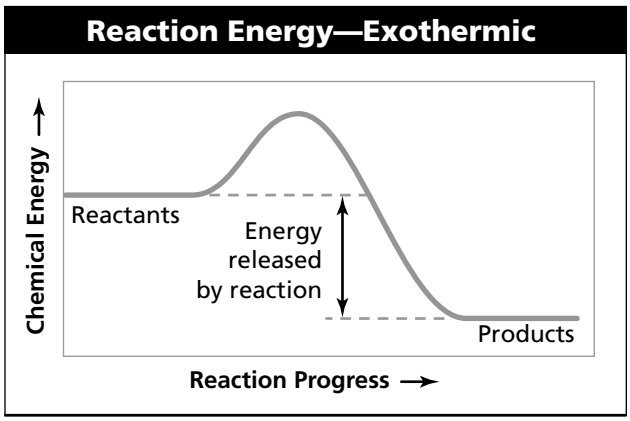
Exothermic and Endothermic Reactions (pages 208–209)

7. During a chemical reaction, energy is either released or absorbed.

8. Is the following sentence true or false? Physical and chemical changes can be either exothermic or endothermic changes. true

9. What is an exothermic reaction? An exothermic reaction is a chemical reaction that releases energy to its surroundings.

10. Is the following sentence true or false? In exothermic reactions, the energy required to break the bonds in the reactants is greater than the energy released as the products form. false



11. Circle the letter of each sentence that is correct for the graph above.
   a. The energy required to break the bonds in the reactants is greater than the energy released as the products form.
   (b.) The energy released as the products form is greater than the energy required to break the bonds in the reactants.
   (c.) The chemical energy of the reactants is greater than the chemical energy of the products.
   d. The chemical energy of the products is greater than the chemical energy of the reactants.

12. In an exothermic reaction, the difference between the chemical energy of the reactants and the chemical energy of the products equals the amount of heat released by the reaction.

13. Where does the energy term appear in the equation for an endothermic reaction? The energy term appears on the left side.

Conservation of Energy (page 209)

14. In an endothermic reaction, heat from the surroundings plus the chemical energy of the reactants is converted into the chemical energy of the products.

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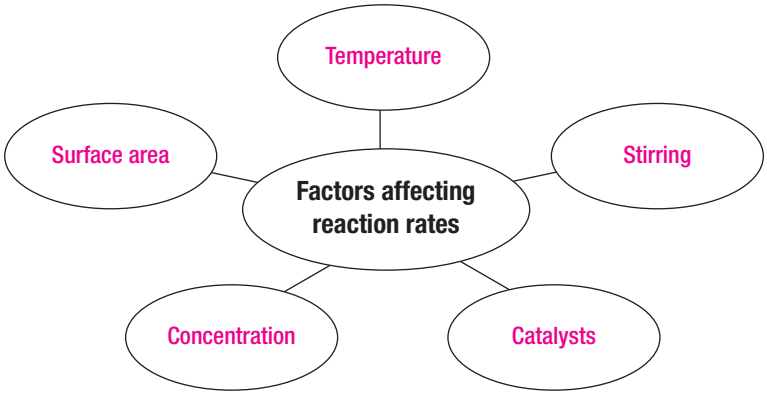
Section 7.4 Reaction Rates

(pages 212–215)

This section discusses the factors that affect reaction rates.

Reading Strategy (page 212)

Building Vocabulary As you read, complete the web diagram below with key terms from this section. For more information on this Reading Strategy, see the **Reading and Study Skills** in the **Skills and Reference Handbook** at the end of your textbook.



Reactions Over Time (page 212)

1. Any change that happens over time can be expressed as a(n) rate.
2. What is a reaction rate? A reaction rate is the rate at which reactants change into products over time.

Factors Affecting Reaction Rates (pages 213–215)

3. Is the following sentence true or false? One way to observe the rate of a reaction is to observe how fast products are being formed. true
4. Is the following sentence true or false? The rate of any reaction is a constant that does not change when the reaction conditions change. false
5. Generally, an increase in temperature will increase the reaction rate.
6. Is the following sentence true or false? Storing milk in a refrigerator stops the reactions that would cause the milk to spoil. false
7. How does an increase in surface area affect the exposure of reactants to one another? An increase in surface area increases the exposure of reactants to one another.

8. Why does increasing the surface area of a reactant tend to increase the reaction rate? The increase in exposure of reactants to one another results in more collisions involving reactant particles. With more collisions, more particles will react.

9. Stirring the reactants in a reaction mixture will generally _____increase_____ the reaction rate.

10. Is the following sentence true or false? Increasing the concentration of the reactants will generally slow down a chemical reaction. _____false_____

11. Is the following sentence true or false? A piece of material dipped in a concentrated dye solution will change color more quickly than in a dilute dye solution. _____true_____

12. Why does an increase in pressure speed up the rate of a reaction involving gases? Concentration of a gas increases with pressure, and an increase in concentration results in a faster reaction rate due to more frequent collisions between reacting particles.

13. What is a catalyst? A catalyst is a substance that affects the rate of a reaction without being used up in the reaction.

14. Circle the letters of the sentences that correctly identify why chemists use catalysts.

(a.) to speed up a reaction

b. to enable a reaction to occur at a higher temperature

c. to slow down a reaction

(d.) to enable a reaction to occur at a lower temperature

15. Is the following sentence true or false? Because a catalyst is quickly consumed in a reaction, it must be added to the reaction mixture over and over again to keep the reaction going. _____false_____

16. Identify where the catalyst V_2O_5 should go in the formula shown and write it in the correct location.

$$2SO_2 + O_2 \xrightarrow{V_2O_5} 2SO_3$$

17. Circle the letter of the correct answer. In the reaction represented by the equation $2H_2O_2 \xrightarrow{Pt} 2H_2O + O_2$, which substance acts as a catalyst?

a. H_2O_2 (b.) Pt

c. H_2O d. O_2

18. One way that a catalyst can lower the energy barrier of a reaction is by providing a surface on which the _____reacting particles_____ can come together.

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Section 7.5 Equilibrium

(pages 216–219)

This section explains physical and chemical equilibria, and describes the factors that affect chemical equilibrium.

Reading Strategy (page 216)

Outlining As you read, make an outline of the most important ideas from this section. For more information on this Reading Strategy, see the **Reading and Study Skills** in the **Skills and Reference Handbook** at the end of your textbook.

I. Equilibrium
  A. Types of Equilibria
    1. Physical equilibrium
    2. Chemical equilibrium
  B. Factors affecting chemical equilibrium
    1. Temperature
    2. Pressure
    3. Concentration

Types of Equilibria (pages 216–217)

1. What is equilibrium? Equilibrium is a state in which the forward and reverse paths of a change take place at the same rate.

2. Circle the letter of the correct answer. In the system described by the equation $H_2O(l) \rightleftharpoons H_2O(g)$, at room temperature, which of the following two physical changes are in equilibrium?

a. sublimation and condensation

b. evaporation and melting

c. sublimation and deposition

(d.) evaporation and condensation

3. What happens when a physical change does not go to completion?

A physical equilibrium is established between the forward and reverse changes.

4. What does the single arrow imply about the reaction described in the following equation?

$$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$$

The single arrow implies that the forward reaction goes to completion.

5. Circle the letter of the correct answer. In the system described by the equation $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, what two reaction types are in equilibrium?

   (a.) synthesis and decomposition
   b. single replacement and decomposition
   c. synthesis and combustion
   d. synthesis and double replacement

6. What happens when a chemical change does not go to completion?
   A chemical equilibrium is established between the forward and reverse reactions.

Factors Affecting Chemical Equilibrium (pages 218–219)

7. Is the following sentence true or false? A change in reaction conditions does not affect a chemical equilibrium. false

8. Circle the letter of each correct answer. The synthesis of ammonia is described by the equation $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + \text{heat}$. Which reaction is favored when the temperature is lowered?

   (a.) the forward reaction
   b. the reverse reaction
   c. the reaction that removes heat from the system
   (d.) the reaction that adds heat to the system

9. Circle the letter of each correct answer. During the synthesis of ammonia, which reaction is favored when hydrogen is added to the system?

   (a.) the forward reaction
   b. the reverse reaction
   (c.) the reaction that removes hydrogen from the system
   d. the reaction that adds hydrogen to the system

10. According to Le Châtelier's principle, how does lowering the concentration of a reaction product affect a chemical equilibrium? Lowering the concentration of a reaction product causes the equilibrium to shift in the direction that forms more of the product.

11. Use the equation $C(s) + H_2O(g) + \text{heat} \rightleftharpoons CO(g) + H_2(g)$ to complete the table below.

An Example of Le Châtelier's Principle		
An increase in	**Shifts the equilibrium so as to**	**Favoring the**
Temperature, concentration of C, or concentration of H_2O	Remove heat	Forward reaction
Pressure	Produce fewer gas molecules	Reverse reaction
Concentration of H_2	Remove H_2, produce fewer gas molecules, or add heat	Reverse reaction

Balancing Chemical Equations

Write a balanced equation for the reaction between potassium and water to produce hydrogen and potassium hydroxide, KOH.

1. Read and Understand

What information are you given?

Reactants: K, H_2O

Products: H_2, KOH

2. Plan and Solve

Write a chemical equation with the reactants on the left side and the products on the right.

$K + H_2O \longrightarrow H_2 + KOH$

This equation is not balanced. The number of hydrogen atoms on the left does not equal the number of hydrogen atoms on the right. Change the coefficients of H_2O and KOH in order to balance the number of hydrogen atoms.

$K + 2H_2O \longrightarrow H_2 + 2KOH$

Change the coefficient of K in order to balance the number of potassium atoms.

$2K + 2H_2O \longrightarrow H_2 + 2KOH$

3. Look Back and Check

Is your answer reasonable?

The number of atoms on the left equals the number of atoms on the right.

Math Skill: Formulas and Equations

You may want to read more about this **Math Skill** in the **Skills and Reference Handbook** at the end of your textbook.

Math Practice

On a separate sheet of paper, solve the following problems.

1. Magnesium burns in the presence of oxygen to form magnesium oxide, MgO. Write a balanced equation for this reaction.

$2Mg + O_2 \longrightarrow 2MgO$

2. Hydrogen peroxide, H_2O_2, decomposes to form water and oxygen. Write a balanced equation for this reaction.

$2H_2O_2 \longrightarrow 2H_2O + O_2$

3. Barium hydroxide, $Ba(OH)_2$, reacts with nitric acid, HNO_3, to form barium nitrate and water. Write a balanced equation for this reaction.

$Ba(OH)_2 + 2HNO_3 \longrightarrow Ba(NO_3)_2 + 2H_2O$

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WordWise

Answer the questions by writing the correct vocabulary term in the blanks. Use the circled letter in each term to find the hidden vocabulary word. Then, write a definition for the hidden word.

Clues	Vocabulary Terms
Describes a reaction that releases energy to its surroundings	e x o t h e (r) m i c
A state in which the forward and reverse paths of a change take place at the same rate	(e) q u i l i b r i u m
A substance that affects the reaction rate without being used up in the reaction	c (a) t a l y s t
A reaction in which a compound breaks down into two or more simpler substances	d e (c) o m p o s i t i o n
A reaction in which two or more substances react to form a single substance	s y n (t) h e s i s
The mass of one mole of a substance	m o l (a) r m a s s
A number that appears before a formula in a chemical equation	c o e f f i c i e (n) t
A reaction in which a substance reacts rapidly with oxygen, often producing heat and light	c o m b u s (t) i o n
The substances formed as the result of a chemical change	p r o d u c t (s)

Hidden Term: r e a c t a n t s

Definition: The substances that undergo change in a chemical reaction